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GEOCHEMISTRY.—*An unusual deposit of aragonite from sea-water.* ROGER C. WELLS,[1] U. S. Geological Survey.

A few months ago the writer had occasion to examine for the United States Bureau of Fisheries some samples of standard sea-water contained in sealed glass tubes as originally furnished by the Copenhagen Laboratory of the Conseil Permanent International de la Mer. The tubes bore the date April 15, 1913, and had remained at rest, awaiting use, for most of the intervening interval. A slight deposit had formed on the inside of several of the tubes, apparently around air bubbles, but nevertheless insoluble in the water after long agitation. As it was feared that the chloride content of the water had changed, very careful determinations were carried out by the gravimetric method, which showed that the chloride content marked on the tubes was substantially correct, the value 19.386 being found, whereas the value on the labels was 19.379 parts of chlorine per 1,000 parts of sea-water.

Attention was next directed to the crystals. A few simple tests showed them to be calcium carbonate. They had a prismatic or needle-like appearance and were arranged in stellate groups. Some of them were a few tenths of a millimeter in length. Dr. E. S. Larsen of the Geological Survey very kindly determined their indices of refraction as follows:

$$\alpha = 1.525 \pm 0.003$$
$$\beta \text{ and } \gamma = 1.675 \pm 0.003$$

The crystals are therefore aragonite, and represent a deposit under apparently very definite conditions. Some of the crystals

[1] Published by permission of the Director, United States Geological Survey.
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were well washed with distilled water, dissolved in acid, and tested for the presence of sulfate. A small amount of sulfate was shown. This agrees with the results of others on natural aragonite formed from the sea.[2] No lead could be detected, and hence the possibility that lead carbonate nuclei determined the formation of the aragonitic form seems to be excluded.

One might account for the deposition of this aragonite on the theory that the water was originally supersaturated with it. It seems more reasonable, however, to assume that some change must have occurred in the water. The most plausible explanation appears to be that very slow attack of the glass by the water caused a series of chemical reactions leading to the deposition of calcium carbonate in the less stable form of aragonite. The carbon dioxide in sea-water exists principally in the form of bicarbonate ions, HCO_3^-, which constitute a very small fraction of all the anions present. Na^+ and Cl^- are present in relatively great excess. The alkali dissolved from the glass yields hydroxide ions, OH^-. The following reactions may be assumed to have occurred:

$$OH^- + HCO_3^- = CO_3^{--} + H_2O \qquad (1)$$

$$CO_3^{--} + Ca^{++} = CaCO_3 \qquad (2)$$

Another possible explanation of the deposit is that some of the carbon dioxide was boiled out of the water before the tubes were sealed up. This explanation, however, seems less probable than the other.

Several writers have pointed out that recently formed deposits of calcium carbonate in nature are likely to be aragonite, whereas the oldest deposits are principally calcite. The facts here noted obviously have a bearing on the deposition of aragonite in nature, the principal difference in conditions being that a loss or gain of carbon dioxide from the water in the tubes was impossible. As there is a large literature on the subject of the deposition of calcium carbonate from sea-water it appeared to the writer worth while to make further analytical determinations on this water with special reference to the question of the solubility of calcium

[2] JOHNSTON, MERWIN, and WILLIAMSON. Amer. Journ. Sci. 41: 508. 1916.

carbonate in sea-water. The results of the determination are as follows. The p_H+ value, from which the hydrogen-ion concentration of the water may be calculated, was found to be 8.18. The titration alkalinity of the water was found to be 0.0019 normal, and the alkalinity caused only by carbonates and bicarbonates 0.0017. The total carbon dioxide was 0.057 gram per liter.

The titration alkalinity and total CO_2 of this water are lower than usually found in sea-water. What is really required, however, to show the degree of saturation with calcium carbonate is an evaluation of the expression $[Ca^{++}][CO_3^{--}]$, in which the brackets represent concentrations of the ions indicated. In the present state of physical chemistry it is extremely difficult to make this evaluation with certainty. Nevertheless, by a series of approximations, the writer has calculated that the expression indicated has the value 7.2×10^{-10} at 25° C. for the water under discussion, as compared with 19.1×10^{-10} for surface sea-water studied at the Marine Laboratory of the Carnegie Institution at Tortugas, Florida. Johnston[3] gives for the solubility-product constant of calcite at 25°: $K = 87 \times 10^{-10}$.

The above values agree well in view of the uncertainties attending the calculations for sea-water. As a matter of fact, however, the solubility-product constant of aragonite is generally thought to be greater than that of calcite, so that the results do not fall in the right order. This may possibly be explained by the lack of information about the temperature to which the tubes containing the standard water had been exposed, or it may indicate that some error exists in the method of calculating the ionic concentrations involved. Or, lastly, the results found may indicate a very slow time adjustment of the solubility. In other words it may be that the solubility-product constant obtained after the course of a very long adjustment is lower than the value deduced from experiments made on fresh material over relatively short intervals.

It seems inadvisable to enter here into a discussion of all the rules and assumptions used in making the above calculations.

[3] Journ. Amer. Chem. Soc. 38: 982. 1916.

What follows is therefore a very brief statement of the methods employed, which may serve to indicate the nature of the problem and the methods used. For the most part the ion concentrations have been calculated from freezing-point data, using certain empirical equations for the ionic equilibria involved.

The calcium concentration of sea-water [Ca] is about 0.0108 molal. This calcium doubtless exists in sea-water in the form of various molecules and complex ions, but on account of the great excess of sodium chloride it seems probable that the other calcium compounds must be very largely transposed into calcium chloride. If so, the calcium-ion concentration can probably best be approximated by considering the equilibrium

$$CaCl_2 \rightleftharpoons Ca^{++} + 2Cl^- \qquad (3)$$

Neglecting intermediate ions and assuming that the ionization of calcium chloride is similar to that of barium chloride, as deduced by G. N. Lewis from freezing-point data,[4] the writer has found that this equilibrium can be represented by the following empirical equation over a moderate range around 0.01 molal.

$$\frac{[Ca^{++}]\,[Cl^-]^2}{[CaCl_2]^{2.034}} = 0.216 \qquad (4)$$

In order to compute the calcium-ion concentration $[Ca^{++}]$ by means of equation (4) it is necessary to assume a value for the chlorine-ion concentration $[Cl^-]$ in sea-water. For the reason given above a quantity of chlorine sufficient to combine with the calcium and magnesium may be subtracted from the total chlorine and the remainder considered to be present as sodium chloride, ionized and un-ionized. The result is about 0.432 mol of sodium chloride. From extrapolation of the curve for the ionization of sodium chloride based on the data of Lewis for dilute solutions it is assumed that the ionization at 0.432 molal would be about 55 per cent. This gives 0.237 for $[Na^+]$ and $[Cl^-]$, which is the value that will be used in calculating the extent to which the ionization of the minor constituents is repressed by the excess of sodium and chlorine ions in sea-water.

From equation (4) it is calculated that when $[Cl^-]$ equals 0.237 and $[Ca^{++}] + [CaCl_2] = 0.0108$, $[Ca^{++}]$ will have the

[4] Journ. Amer. Chem. Soc. 41: 1959. 1919.

value 0.000359. If the assumptions made are approximately correct this figure shows that the ionization of the calcium compounds in sea-water is enormously repressed by the excess of chlorine ions.

In the same way, for the equilibrium

$$NaHCO_3 \rightleftharpoons [Na^+] + [HCO_3^-] \qquad (5)$$

the following equation was found to hold over a moderate range around the concentration 0.002 molal. The ionization is taken as equal to that of sodium chloride at the same concentrations.

$$\frac{[Na^+]\,[HCO_3^-]}{[NaHCO_3]^{1.27}} = 0.746 \qquad (6)$$

This yields, when $[Na^+] = 0.237$, $[HCO_3^-] = 3.15[NaHCO_3]^{1.27}$. A consideration of the relations required by this equation shows that the ionization of the bicarbonates in sea-water must be largely repressed in spite of their low concentration. For simplicity the un-ionized carbonate and bicarbonate in the solution under study will be considered to be present as the sodium compounds, a logical view on account of the great excess of $[Na^+]$.

The ionic concentrations $[HCO_3^-]$ and $[CO_3^{--}]$ may now be evaluated from the analytical data for the water under consideration. Let a, b, c, d, and e represent the molal concentrations of H_2CO_3(the free CO_2), CO_3^{--}, HCO_3^-, Na_2CO_3, and $NaHCO_3$, respectively. The following equations are available:

$$44(a + b + c + d + e) = 0.057 \qquad (7)$$

$$2b + c + 2d + e = 0.0017 \qquad (8)$$

$$c = 3.15\, e^{1.27} \qquad (9)$$

$$c = 53a \qquad (10)$$

$$b = 0.00743c \qquad (11)$$

The last two equations are derived from the equations

$$[HCO_3^-] = \frac{k_1[H_2CO_3]}{[H^+]} \qquad (12)$$

$$[CO_3^{--}] = \frac{k_2[HCO_3^-]}{[H^+]} \qquad (13)$$

in which k_1, the first ionization constant of carbonic acid, has the value 3.50×10^{-7} at 25°, according to Kendall,[5] and k_2, the

[5] Journ. Amer. Chem. Soc. 38: 1486. 1916.

second ionization constant, is given by Seyler and Lloyd[6] as 4.91×10^{-11}. The value for $[H^+]$ is 6.61×10^{-9} for the water under scrutiny, which yields equations (10) and (11) given above.

It may be noted in passing that the free CO_2, or H_2CO_3, must have a very small concentration in this water as $[HCO_3^-]$, according to equation (10), must equal 53 $[H_2CO_3]$, thus requiring a very large proportion of the total CO_2.

The solution of equations (7) to (11) gives $[H_2CO_3] = 4.49 \times 10^{-6}$, $[CO_3^{--}] = 1.96 \times 10^{-6}$, $[HCO_3^-] = 2.64 \times 10^{-4}$. From the preceding data $[Ca^{++}][CO_3^{--}] = 3.59 \times 10^{-4} \times 1.96 \times 10^{-6} = 7.23 \times 10^{-10}$ for the Copenhagen water.

The analytical data for unaltered surface sea-water studied at Tortugas are: $P_H+ = 8.20$, titration carbonate alkalinity = 0.00223, total CO_2 = 0.090 gram per liter. Calculations similar to those indicated above give the results shown below with the values first obtained for the Copenhagen water.

	$[H^+]$	$[HCO_3^-]$	$[CO_3^{--}]$	$[Ca^{++}][CO_3^{--}]$
Copenhagen water.....	6.61×10^{-9}	2.64×10^{-4}	1.96×10^{-6}	7.2×10^{-10}
Tortugas water.....	6.03×10^{-9}	6.85×10^{-4}	5.33×10^{-6}	19.1×10^{-10}

It may be noted that there is little difference in $[H^+]$ in the two waters, the principal differences being in the figures for $[HCO_3^-]$ and $[CO_3^{--}]$. This illustrates the buffer action of the carbonates in sea-water.

With reference to the low "solubility-product" value for the Copenhagen water, the Tortugas water appears to be fully saturated with calcium carbonate. A similar conclusion was reached by J. F. McClendon from experiments in which sea-water was agitated with calcite and aragonite, and the changes in p_H+ and titration alkalinity observed.[7] The Copenhagen water, however, shows a relatively large loss in total CO_2. It is hoped that further data for sea-water collected under definite conditions will be available shortly. It is also hoped that in a future paper attention can be given to the possibility of improving the expressions for the mass-law equilibria used in the present paper.

[6] Journ. Chem. Soc. London 111: 158. 1917–1918.

[7] Carnegie Institution Publication 252: 255.

PHYSICAL CHEMISTRY.—*Reduction potentials of mixtures of indigo and indigo white, and of mixtures of methylene blue and methylene white.*[1] W. MANSFIELD CLARK. Dairy Division, Bureau of Animal Industry, United States Department of Agriculture.

Oxidation-reduction indicators have been used to some extent in volumetric analysis, but it is in various biochemical studies that they find their widest and most interesting applications. The reduction of methylene blue by bacteria in milk is regarded as one of the first observable evidences of bacterial action. Not all bacteria reduce this dye, and this differential property is therefore used in the identification and biochemical classification of species. An important class of bacteria seem to require the complete absence of oxygen before they will grow, and since reduced methlyene blue and reduced indigo can be used to detect minute traces of oxygen these indicators have played a most interesting part in the development of conceptions regarding the so-called anaerobic state. Anaerobiosis is a large subject whose various phases have not yet been satisfactorily resolved. There is abundant evidence, however, that one or another phase of it is intimately associated with the reducing tendency of cellular activity in general. The recognition of this tendency has come about in large measure through the use of reduction indicators such as methylene blue. It has even been claimed that reduction of this dye by a tissue indicates the presence of life and the failure of reduction indicates the death of the cells. Yet there seem to exist different powers of reduction in various tissues, as was shown in Ehrlich's classic work and confirmed by some of the more recent staining investigations of the histologists.

So far as the writer is aware such indicators have not been regarded in their possible relation to oxidation reduction potentials in a manner analogous to the now well-systematized relation of hydrogen-ion indicators to hydrogen-electrode potentials. That such a relationship if established will aid in the interpreta-

[1] Published by permission of the Secretary of Agriculture. Received February 12, 1920.

tion of various biochemical phenomena will be evident, but the significance of such data is of broader scope, because the efforts that have previously been made to bring organic compounds within the range of potential measurements have yielded few data of value.

In a subsequent paper the writer hopes to discuss in detail some of the theoretical aspects concerned in the measurement of reduction potentials, together with certain biochemical applications. But for the present only the data obtained with indigo and methylene blue will be presented.

The original sample of the indigo used in the following experiments was labeled "Indigo sodium sulfonate dye." Mr. Zoller made a sulfur determination upon the purified material which indicated that it was $C_{16}H_9N_2O_2SO_3Na$.

Mr. Zoller prepared from the original material some purer material by precipitating the dye from its aqueous solution with pure alcohol. This was dried in a current of air and then in an air oven at 105° C. It was this material that was used in the following experiments.

The methylene blue was prepared by Mr. Zoller from Schumaker and Busch's "medicinal methylene blue." For the purification the method of Bernthsen[2] was followed in the main. The crystals were dried *in vacuo* over stick KOH and concentrated sulfuric acid. It thus attained constant weight.

The most convenient form of these two substances is their oxidized state. Therefore it is required to find a reducing agent whose own oxidation-reduction equilibrium does not seriously overlap the range of potential covered by the dyes in question. Titanium trichlorid has been used by Knecht and Hibbert[3] for the quantitative estimation of methylene blue, indigo, and a variety of other dyes. However it is customarily used in very acid solutions and in a range of P_H which would have little significance for biochemical studies. Titanium, however, like iron, enters into complexes with hydroxy-acids and then remains

[2] Ann. 230: 139. 1885.

[3] *New reduction methods in volumetric analysis.*

unprecipitated even in markedly alkaline solution. Citric acid is one of the hydroxy-acids which form such complexes, and it also makes an excellent material with which to buffer the hydrogen-ion concentration throughout a considerable range of P_H. Reduced titanium in the form of titanium trichlorid was therefore added to citrate and the solution was buffered either with citrate mixtures alone or with citrate in addition to a preponderance of other buffer mixtures. The buffer salts were kept about tenth molecular while the titantium was present at about 0.003 N concentration. The dye solution containing about the same normal concentration of the dye was buffered by the salt solution. Thus a constant p_H was guaranteed throughout the titration. Hydrogen-electrode measurement of these mixtures was impracticable because of the oxidizing action of the dye in the one case and of the unreduced titanium in the other. Therefore dependence was placed on the hydrogen-electrode measurements of the P_H of the buffer solutions made up without the oxidizing and reducing agents. The addition of these reagents in concentrations of only 0.003 N should not have seriously affected the P_H of 0.1 molecular buffer mixtures.

The procedure was as follows:

The indicator solution was placed in an electrode vessel similar to that described by Hostetter and Roberts[4] for the electrometric titration of iron, but provided with gas-tight connections. The vessel was then flushed with nitrogen from a tank. This tank nitrogen contained a little oxygen and was therefore run through a heated tube containing copper wire previously reduced with hydrogen. The solution was then boiled in a vigorous current of nitrogen and while steam was still escaping the tip of the burette containing the reducing agent was forced into a tight-fitting hole on the head of the apparatus. There were then passing into the flask through the "head": The burette tip which delivered the reducing agent above the surface of the solution; the entering tube for the nitrogen which delivered the gas above the middle of the solution surface; the exit for the gas, which was flush with

[4] Journ. Amer. Chem. Soc. 41: 1337. 1919.

the surface of the stopper; the calomel electrode arm drawn to a fine gooseneck tip; and the electrode. The electrode was a platinum wire wound as a spiral and plated with gold. The electrode itself was kept immersed in the solution. It was fused into a glass tube carrying a mercury contact. Since it was not the intention to make a careful study of liquid junction potentials these were reduced so far as is practicable by the customary use of saturated potassium chlorid. This was accomplished by employing directly the "saturated" calomel electrode. Its potential was frequently checked against that of four very constant and carefully made tenth-normal calomel electrodes whose average potential in terms of the normal hydrogen electrode[5] was considered to be +0.3370. Both calomel electrode and titration vessel were immersed in an oil bath maintained at 30° C. The potentiometer equipment was that used in the writer's previous work with the hydrogen electrode. Its principal features were a Leeds and Northrup type *K* potentiometer and the same company's type *R* galvanometer with a megohm sensitivity of 1973.

The reducing agent, as mentioned before, was titanium in the presence of citrate and an excess of buffer. Since these solutions are unstable in the presence of oxygen they were prepared by adding the titanium to the previously prepared buffer mixture, quickly bubbling oxygen-free nitrogen through it, and flushing the whole system, burette and reservoir, with nitrogen.

The titrating vessel was so arranged that it could be thoroughly shaken after each addition of reducing agent. When this was done electrode equilibrium was reached within a minute or two except in certain of the more extreme conditions.

In the following tables there are given in the first column the number of cubic centimeters of reducing agent added. By plotting these against the potential it will be found that at certain p_H values there is not the sharp-end point that occurs at other acidities. Such relationships will place upon a more quantitative basis the empirical findings of Knecht and Hibbert, who discovered that a sharp-end point in the titration of many dyes such

[5] See CLARK and LUBS. Journ. Biol. Chem. 25: 479.

as indigo can be obtained only in the presence of such substances as tartrates. Perhaps there is a specific action here to be accounted for, but the more probable explanation is that the proper relations for a sharp-end point are determined by the hydrogen-ion concentration, which mixtures such as the tartrates can control.

In the next column of the tables is given the percentage reduction estimated from the total amount of reducing agent required to completely reduce the dye. As was just mentioned, it was not always possible to estimate with precision the total requirement by determining the end point potentiometrically. In such cases the disappearance of color or merely a judgment of the end point from the form of the titration curve was used. In any case the error was not large.

In the third column are given the single electrode potentials observed. These were determined from the potential of the calomel electrode and the difference of potential between calomel and gold electrodes. In each case the standard reference value was used, so that the values given are in terms of the hypothetical normal hydrogen electrode. The sign indicates the sign of the electrode.

Since both methylene blue and indigo are reduced in accordance with reactions which may be written as

$$\text{Dye} + 2 \text{ electrons} = \text{reduced dye},$$

the potential equation of Peters becomes at 30° C.

$$E \text{ observed} = E_0 + \frac{0.06}{2} \log \frac{[\text{Oxidation product}]}{[\text{Reduction product}]}$$

The ratios

$$\frac{\text{Concentration of oxidation product}}{\text{Concentration of reduced product}}$$

multiplied by 0.03 are given in column four of the tables. In the last column are given the values of E_0 obtained from the application of the equation written above.

It will be seen that there is a substantial constancy in the values

of E_o. Since no correction had been made for the true concentration of these products as influenced by the various factors of the solution the agreement is remarkable in some instances.

In the case of methylene blue it will be noted that only the potentials taken during the early part of the titration are given when the p_H of the solution is greater than 4.55. This is because in the more alkaline solutions the methylene white base precipitates. During the early part of the titration the solution remains clear and the potentials follow a smooth curve which begins normally. The curve of potentials soon tends to flatten and there comes a moment when the potential rises. It is at this moment that the reduced compound separates from its now supersaturated solution. Its removal leaves the oxidation product in greater excess and the potential of the electrode becomes more positive. Perhaps there is at hand in such phenomena the means of accurately determining the solubility of such compounds.

When there thus arose the impossibility of obtaining a complete titration curve of methylene blue at the concentration used, the part of the curve that was obtained was plotted and overlaid with the theoretical form which applies to all the curves. The probable position considered in conjunction with the calculated values of E_o which were obtained, determined the "probable values" of E_o which are given.

It is sometimes customary to consider a reduction electrode as a hydrogen electrode under diminished hydrogen pressure. Although the hydrogen pressures so estimated become impossibly small in some instances this may be a legitimate way of correlating reduction potentials at different acidities. We may consider the relation in the following form.

Suppose our reduction electrode were a hydrogen electrode under that pressure of molecular hydrogen which is in equilibrium with the oxidation-reduction products of the solution. Let the same solution be in contact with a hydrogen electrode under a pressure of one atmosphere of hydrogen, and let the two electrodes and the solution be connected as in a cell.

The potential of this cell will then be at 30° C.

$$E_R - E_H = 0.03 \log \frac{I}{(H_2)}$$

where E_R is the potential of the reduction electrode, E_H that of the hydrogen electrode and (H_2) represents the pressure in atmospheres of the hydrogen at the reduction electrode.

As mentioned before, we cannot accurately measure the hydrogen-electrode potential of the mixtures now under consideration, but the hydrogen-electrode potentials of the buffer mixtures without the small proportion of the oxidizing agents were carefully measured. These are given in table 13 together with the reduction potentials. The values of $\log \frac{I}{(H_2)}$ for methylene blue and for indigo differ sufficiently to distinguish between the two substances, but it may appear that the agreement among the values for either one of the substances is not satisfactory. However, when these values are plotted against p_H they will be found to fall upon a fairly smooth curve.

We may just as well consider only the differences of potential instead of calculating the hypothetical hydrogen pressure as was done above, but the values of $\log \frac{I}{H_2}$ furnish convenient numbers with which to characterize the intensity of oxidation-reduction actions.

TABLE 1

REDUCTION OF INDIGO BY TITANIUM AT P_H 1.55
Buffer: $M/10$ KCl with HCl

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_o
0.0	0.0	+0.338	....	.....
1.0	6.4	+0.2517	+0.0349	+(0.2168)
2.0	12.8	+0.2365	+0.0250	+(0.2115)
3.0	19.2	+0.2276	+0.0187	+0.2089
4.0	25.6	+0.2220	+0.0139	+0.2081
5.0	32.1	+0.2176	+0.0098	+0.2078
6.0	38.5	+0.2138	+0.0061	+0.2077
7.0	44.8	+0.2104	+0.0027	+0.2077

TABLE 1—(*Continued*)

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_o
8.0	51.3	+0.2070	—0.0007	+0.2077
9.0	57.7	+0.2035	—0.0041	+0.2076
10.0	64.1	+0.2000	—0.0076	+0.2076
11.0	70.5	+0.1961	—0.0114	+0.2075
12.0	76.9	+0.1917	—0.0157	+0.2074
13.0	83.3	+0.1859	—0.0210	+0.2069
14.0	89.8	+0.1784	—0.0283	+0.2067
15.0	96.2	+0.1657	....	.....
15.5	99.4	+0.1505	....	.....
15.6	100.0	End point	....	.....
15.7	.....	+0.1414	....	.....
				Average, +0.2076

TABLE 2

REDUCTION OF INDIGO BY TITANIUM AT P_H 2.45
Buffer Solution: $M/10$ Citrate with HCl

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_o
0.0	0.0	+0.3962	.....	.....
1.0	3.6	+0.2076	+0.0429	+(0.1647)
2.0	7.1	+0.1899	+0.0334	+(0.1565)
3.0	10.7	+0.1813	+0.0276	+(0.1537)
4.0	14.3	+0.1746	+0.0233	+0.1513
5.0	17.9	+0.1712	+0.0199	+0.1513
6.0	21.4	+0.1682	+0.0170	+0.1512
7.0	25.0	+0.1655	+0.0143	+0.1512
8.0	28.6	+0.1628	+0.0119	+0.1509
9.0	32.2	+0.1605	+0.0097	+0.1508
10.0	35.7	+0.1583	+0.0077	+0.1506
11.0	39.3	+0.1562	+0.0057	+0.1505
12.0	42.9	+0.1541	+0.0037	+0.1504
13.0	46.4	+0.1523	+0.0018	+0.1505
14.0	50.0	+0.1503	±0.0000	+0.1503
15.0	53.6	+0.1484	—0.0018	+0.1502
16.0	57.1	+0.1464	—0.0037	+0.1501
17.0	60.7	+0.1444	—0.0057	+0.1501
18.0	64.3	+0.1424	—0.0077	+0.1501

TABLE 2—(*Continued*)

Cc. Ti solution	Per cent reduction	E_H	0,03 log ox./red.	E_o
19.0	67.9	+0.1402	—0.0097	+0.1499
20.0	71.4	+0.1380	—0.0119	+0.1499
22.0	78.6	+0.1329	—0.0170	+0.1499
24.0	85.7	+0.1260	—0.0233	+0.1493
25.0	89.3	+0.1215	—0.0276	+(0.1491)
26.0	92.9	+0.1152	.....	.....
27.0	96.4	+0.1051	.....	.....
28.0	100.0	+0.082	.....	.....
				Average, +0.1504

TABLE 3

REDUCTION OF INDIGO BY TITANIUM AT P_H 2.87

Buffer Solution: *M*/10 Citrate with HCl

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_o
0.0	0.0	+0.3642	.....	.....
1.0	8.8	+0.1595	+0.0305	+(0.1290)
2.0	17.5	+0.1462	+0.0202	+0.1260
3.0	26.3	+0.1387	+0.0134	+0.1253
4.0	35.1	+0.1327	+0.0080	+0.1247
5.0	43.9	+0.1278	+0.0032	+0.1246
6.0	52.6	+0.1232	—0.0014	+0.1246
7.0	61.4	+0.1183	—0.0061	+0.1244
8.0	70.2	+0.1133	—0.0112	+0.1245
9.0	78.9	+0.1069	—0.0172	+0.1241
9.5	83.3	+0.1032	—0.0210	+0.1242
10.0	87.7	+0.0984	—0.0256	+0.1240
10.8	94.7	+0.0857	.....	.....
11.0	96.5	+0.0808	.....	.....
11.2	98.2	+0.0721	.....	.....
11.3	99.1	+0.064	.....	.....
11.4	100.0	+0.055	.....	.....
				Average, +0.1246

TABLE 4

REDUCTION OF INDIGO BY TITANIUM AT P_H 4.55

Indigo and Titanium about 0.003 *N*

Buffer Solution: *N*/10 Citrate with HCl

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_0
0.0	0.0	+0.3522	.....	.....
0.5	4.4	+0.0812	+0.0401	+(0.0411)
1.0	8.9	+0.0566	+0.0304	+(0.0262)
2.0	17.7	+0.0427	+0.0200	+0.0227
3.0	26.6	+0.0352	+0.0133	+0.0219
4.0	35.4	+0.0291	+0.0078	+0.0213
5.0	44.2	+0.0240	+0.0030	+0.0210
6.0	53.1	+0.190	−0.0016	+0.0206
7.0	61.9	+0.0140	−0.0064	+0.0204
8.0	70.8	+0.0085	−0.0115	+0.0200
9.0	79.6	+0.0021	−0.0178	+0.0199
10.0	88.5	−0.0076	−0.0266	+0.0190
10.5	92.9	−0.0152	−0.0335	+0.0183
11.0	97.3	−0.0334	−0.0469	+(0.0135)
11.2	99.1	−0.0510	.....	.....
11.3	110.0	−0.0620	End point	.....
				Average, +0.0205

TABLE 5

REDUCTION OF INDIGO BY TITANIUM AT P_H 6.69

Indigo and Titanium about 0.003 *N*

Buffer Solution: *M*/10 Na_2HPO, *M*/40 Citrate with HCl

Cc. Ti solution	Per cent reduction	E_H	0.030 log ox./red.	E_0
0.0	0.0	−0.022	.....	.....
0.5	4.6	−0.0588	+0.0397	−(0.0985)
1.0	9.1	−0.0688	+0.0300	−0.0988
2.0	18.2	−0.0802	+0.0196	−0.0998
3.0	27.3	−0.0895	+0.0128	−0.1023
4.0	36.4	−0.0953	+0.0073	−0.1026
5.0	45.5	−0.0982	+0.0024	−0.1006
6.0	54.5	−0.1038	−0.0024	−0.1014
7.0	63.6	−0.1081	−0.0073	−0.1008
8.0	72.7	−0.1133	−0.0128	−0.1005

TABLE 5—(*Continued*)

Cc. Ti solution	Per cent reduction	E_H	0.030 log ox./red.	E_o
9.0	81.8	—0.1208	—0.0196	—0.1012
10.0	90.9	—0.1321	—0.0300	—0.1021
10.5	95.5	—0.1438	—0.0397	—(0.1041)
10.7	97.3	—0.1533	.....	.....
10.9	99.1	—0.1737	.....	.....
11.0	100.0	—0.198	End point	.....
				Average, —0.1010

TABLE 6

TITRATION OF INDIGO BY TITANIUM AT P_H 8.58
Buffer Solution: $M/10$ Borate, $M/40$ Citrate with HCl

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_o
0.0	0.0	+0.074	.....	.....
1.0	8.3	—0.1266	+0.0312	—(0.1578)
2.0	16.7	—0.1398	+0.0210	—0.1608
3.0	25.0	—0.1466	+0.0143	—0.1609
4.0	33.3	—0.1518	+0.0090	—0.1608
5.0	41.7	—0.1563	+0.0044	—0.1607
6.0	50.0	—0.1603	+0.0000	—0.1603
7.0	58.3	—0.1647	—0.0044	—0.1603
8.0	66.7	—0.1694	—0.0090	—0.1604
9.0	75.0	—0.1743	—0.0143	—0.1600
10.0	83.3	—0.1814	—0.0210	—0.1604
11.0	91.7	—0.1931	—0.0312	—(0.1619)
12.0	100.0	—0.2438	End point	.....
				Average, —0.1609

TABLE 7

REDUCTION OF METHYLENE BLUE BY TITANIUM AT P_H 1.55
Buffer Solution: $M/10$ KCl with HCl

Cc. Ti solution	Per cent reduction	E_H	0 03 log ox./red.	E_o
0.0	0.0	+0.4812	.....	.....
1.0	4.3	+0.4216	+0.0404	+0.3812
2.0	8.6	+0.4112	+0.0308	+0.3804
3.0	12.9	+0.4050	+0.0248	+0.3802

TABLE 7—(*Continued*)

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_o
4.0	17.2	+0.4006	+0.0204	+0.3802
5.0	21.6	+0.3969	+0.0168	+0.3801
6.0	25.9	+0.3937	+0.0137	+0.3800
7.0	30.2	+0.3909	+0.0109	+0.3800
8.0	34.5	+0.3884	+0.0084	+0.3800
9.0	38.8	+0.3861	+0.0059	+0.3802
10.0	43.1	+0.3838	+0.0036	+0.3802
11.0	47.4	+0.3817	+0.0014	+0.3803
12.0	51.7	+0.3796	−0.0009	+0.3805
13.0	56.0	+0.3677	−0.0032	+0.3808
14.0	60.3	+0.3755	−0.0055	+0.3810
15.0	64.7	+0.3733	−0.0079	+0.3812
16.0	69.0	+0.3712	−0.0104	+0.3816
17.0	73.3	+0.3688	−0.0131	+0.3819
18.0	77.6	+0.3663	−0.0162	+0.3825
19.0	81.9	+0.3632	−0.0197	+0.3829
20.0	86.2	+0.3595	−0.0239	+0.3834
21.0	90.5	+0.3542	−0.0294	+0.3836
22.0	94.8	+0.3442	−0.0379	+0.3821
23.2	100.0	+0.3095	.....	.....
				Average, +0.3811

TABLE 8

REDUCTION OF METHYLENE BLUE BY TITANIUM AT P_H 2.45

Buffer Solution: *M*/10 Citrate with HCl

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_o
0.0	0.0	+0.4242	.....	.....
2.0	3.4	+0.3474	+0.0438	+0.3036
4.0	6.7	+0.3354	+0.0343	+0.3011
6.0	10.1	+0.3292	+0.0285	+0.3007
8.0	13.4	+0.3248	+0.0243	+0.3005
10.0	16.8	+0.3215	+0.0209	+0.3006
14.0	23.5	+0.3163	+0.0154	+0.3009
18.0	30.3	+0.3129	+0.0109	+0.3020

TABLE 8—(*Continued*)

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_o
22.0	37.0	+0.3102	+0.0069	+0.3033
25.0	42.0	+0.3086	+0.0042	+0.3044
30.0	50.4	+0.3044	—0.0003	+0.3047
34.0	57.1	+0.3012	—0.0037	+0.3049
38.0	63.9	+0.2984	—0.0073	+0.3057
42.0	70.6	+0.2957	—0.0113	+0.3070
46.0	77.3	+0.2923	—0.0161	+0.3084
50.0	84.0	+0.2880	—0.0216	+0.3096
54.0	90.8	+0.2805	—0.0300	+0.3105
58.0	97.5	+0.2592	—0.0475	+0.3067
59.0	99.2	+0.2382	—0.0621	+0.3003
59.5	100.0	+0.2272	.....	.....
				Average, +0.3042

TABLE 9

REDUCTION OF METHYLENE BLUE BY TITANIUM AT P_H 2.87
Buffer Solution: *M*/10 Citrate with HCl

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_o
0 0	0.0	+0.3902	.....	.....
2.0	12.0	+0.2877	+0.0259	+0.2618
4.0	24.1	+0.2763	+0.0149	+0.2614
6.0	36.1	+0.2690	+0.0074	+0.2616
8.0	48.2	+0.2636	+0.009	+0.2627
10.0	60.2	+0.2585	—0.0054	+0.2639
12.0	72.3	+0.2531	—0.0125	+0.2656
14.0	84.3	+0.2458	—0.0219	+0.2677
16.0	96.4	+0.2270	—0.0426	+0.2696
16.2	97.6	+0.2207	.....	.....
16.4	98.8	+0.2096	.....	.....
16.6	100.0	+0.1832	.....	.....
				Average, +0.2641

TABLE 10

REDUCTION OF METHYLENE BLUE BY TITANIUM AT P_H 4.55

Methylene Blue and Titanium about 0.003 *N*

Buffer Solution: *M*/10 Citrate with HCl

Cc. Ti solution	Per cent reduction	E_H	0.03 lo ox./red.	E_o
0.0	0.0	+0.275	.....	.....
0.5	2.9	+0.179	+0.0459	+(0.133)
1.0	5.8	+0.1617	+0.0364	+(0.1253)
2.0	11.6	+0.1429	+0.0265	+0.1164
3.0	17.3	+0.1385	+0.0204	+0.1181
4.0	23.1	+0.1330	+0.0156	+0.1174
5.0	28.9	+0.1287	+0.0117	+0.1170
6.0	34.7	+0.1251	+0.0082	+0.1169
7.0	40.5	+0.1218	+0.0050	+0.1168
8.0	46.2	+0.1190	+0.0020	+0.1170
9.0	52.0	+0.1162	−0.0011	+0.1173
10.0	57.8	+0.1136	−0.0041	+0.1177
11.0	63.6	+0.1109	−0.0073	+0.1182
12.0	69.4	+0.1081	−0.0107	+0.1188
13.0	75.1	+0.1050	−0.0144	+0.1194
14.0	80.9	+0.1015	−0.0188	+0.1203
15.0	86.7	+0.0967	−0.0245	+(0.1212)
16.0	92.5	+0.0885	−0.0327	+(0.1212)
17.0	98.3	+0.0537	−0.0524	+(0.1061)
17.2	99.4	+0.015	.....	.....
17.3	100.0	−0.026	End point	.....
				Average, +0.1178

TABLE 11

REDUCTION OF METHYLENE BLUE BY TITANIUM AT P_H 6.69

Buffer Solution: *M*/10 Na_2HPO_4, *M*/40 Citrate with HCl

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_o
0.0	0.0	+0.345	.....	.....
0.5	2.6	+0.0677	+0.0471	+0.0206
1.0	5.2	+0.0481	+0.0377	+0.0104
2.0	10.5	+0.0351	+0.0280	+0.0071
3.0	15.7	+0.0295	+0.0219	+0.0076
4.0	20.9	+0.0264	+0.0173	+0.0091
5.0	26.2	+0.039	.....	.....

Methylene white precipitate formed.

Potentials unsteady.

TABLE 11—(*Continued*)

Cc. Ti solution	Per cent reduction	E_H	0.03 $\log \frac{ox.}{red.}$	E_o
18.3	95.8	—0.056	.....	.....
19.1	100.0	—0.122	.....	.....
		End point		

Probable value of E_o + 0.007.

TABLE 12

REDUCTION OF METHYLENE BLUE BY TITANIUM AT P_H 8.58

Buffer Solution: *M*/10 Borate, *M*/40 Citrate with HCl

Cc. Ti solution	Per cent reduction	E_H	0.03 log ox./red.	E_o
0.05	0.2	+0.0018	.....	.....
0.5	2.2	—0.0136	+0.0496	—0.0632
1.0	4.4	—0.0190	+0.0403	—0.0593
2.0	8.7	—0.0244	+0.0306	—0.0550
3.0	13.0	—0.0278	+0.0247	—0.0525
4.0	17.4	—0.0300	+0.0203	—0.0503
5.0	21.7	—0.0315	+0.0167	—0.0482
6.0	26.1	—0.0322	.....	.....
7.0	30.4	—0.0322	.....	.....

Methylene white precipitate separates.
Potentials unsteady. End point by color about 23.0 cc. Ti.
Probable value of E_o — 0.050.

TABLE 13

COMPARISON OF CHARACTERISTIC DATA OF INDIGO WITH THAT OF METHYLENE BLUE

Indigo

P_H	H electrode potential	Reduction potential	Difference	$\log 1/H_2$
1.55	—0.0936	+0.2076	0.3012	10.0
2.45	—0.1471	+0.1504	0.2975	9.9
2.87	—0.1727	+0.1246	0.3073	9.9
4.55	—0.2737	+0.0205	0.2942	9.8
6.69	—0.4021	—0.1010	0.3011	10.0
8.58	—0.5155	—0.1609	0.3546	11.8

TABLE 13—(*Continued*)
Methylene Blue

P_H	H electrode potential	Reduction potential	Difference	log $1/H_2$
1.55	—0.0936	+0.3811	0.4747	15.8
2.45	—0.1471	+0.3042	0.4513	15.1
2.87	—0.1724	+0.2641	0.4365	14.6
4.56	—0.2737	+0.1178	0.3915	13.1
6.69	—0.4021	+0.007	0.409	13.6
8.58	—0.5155	—0.05	0.47	15.3

PETROGRAPHY.—*Italite: a new leucite rock.* HENRY S. WASHINGTON. Geophysical Laboratory, Carnegie Institution of Washington.[1]

Last October, while in Rome, there was brought to my attention by Dr. G. A. Blanc, of the University of Rome, and Ing. F. Jourdain, a small piece of a very remarkable leucite rock, that they had collected from a flow on the west slope of the volcano of Rocca Monfina, north of Naples. I am indebted to their kindness for the small specimen and for permission to publish the results of my study. A full description will be published later in the *American Journal of Science.*

The rock is rather coarsely granular and very friable, composed almost wholly (90 per cent) of spheroidal crystals of leucite from 3 to 5 mm. in diameter. These show the twinned structure remarkably well and carry few inclusions, these not being regularly arranged. These crystals are cemented by a small amount of a colorless glass, which contains many margaritic microlites. There are also present, in very small amount, prismoids of aegirite-augite and grains of titaniferous melanite, with rare small crystals of biotite, magnetite, and apatite. The glass and the microstructure show that the rock is a lava, not a tuff.

Chemical analysis yielded the results shown in table 1.

The rock is seen to have a quite exceptional composition, and shows the highest percentage for K_2O yet recorded, the next highest (11.91) being that of an orendite from the Leucite Hills,

[1] Received March 30, 1920.

closely followed by some Italian leucite trachytes and tephrites. The noselite, whose presence is indicated by the SO_3 and high CaO, probably forms part of the glass, as does melilite, the presence of which is also indicated by the norm.

In the quantitative classification the position of the rock is shown by the symbol I.9.1.1, and the new perpotassic subrang is called *monfinose*. No rock at all analogous to this is represented in the usual or modal classifications and, though the name "leucitite" might logically be applied to it, implying a rock composed essentially of leucite, as suggested by Cross many years ago, this name cannot be used, because of its present connotation and the inadvisability of redefining old names. The new name given the rock is *italite*, after the country in which it occurs, and which is so famous for its abundance in leucitic lavas.

A partial analysis (made on 0.0639 gram) of the garnet showed that it is a highly titaniferous melanite, analogous to schorlomite. Its refractive index, $n = 1.94$, is remarkably high, in which it resembles other titaniferous garnets, whose refractive indexes have also been recently determined by Merwin.

TABLE 1

ANALYSIS OF ITALITE

SiO_2	51.02	CO_2	None
Al_2O_3	22.21	TiO_2	0.57
Fe_2O_3	1.48	ZrO_2	0.06
FeO	0.57	P_2O_5	0.02
MgO	0.14	SO_3	0.76
CaO	2.31	Cl	0.08
Na_2O	1.67	$(Ce,Y)_2O_3$	Trace
K_2O	17.94	MnO	0.01
H_2O^+	0.82	BaO	0.20
H_2O^-	0.11		
			99.97

Supplementary Note.—While the above was in press I have studied another similar, remarkable leucite rock, that forms an "ejected block" at Monte Somma. It is much like the italite

just described, both megascopically and microscopically, the leucite crystals being almost identical. Small crystals of greenish, non-pleochroic augite are, however, more abundant, and there is considerable melilite, in thickly tabular crystals interstitial between the leucites and in cavities in the specimen. The rock contains no glass, the melilite taking its place, and neither garnet, biotite, nor olivine is present. The rock contains about 65 per cent of leucite, 18 of melilite, 20 of pyroxene, and 2 of magnetite. An analysis gave the results shown in table 2.

TABLE 2

ANALYSIS OF VESBITE

SiO_2	45.49	H_2O^+	0.93
Al_2O_3	17.66	H_2O^-	0.05
Fe_2O_3	0.81	TiO_2	0.13
FeO	1.45	P_2O_5	0.16
MgO	4.27	SO_3	None
CaO	16.72	Cl	0.03
Na_2O	1.66	MnO	Trace
K_2O	11.44		
			100.80

This rock is essentially a melilite italite, and the name of *vesbite* (from a Latin name of Vesuvius) is given it. Vesbite is intermediate between italite and venanzite, and is also related to the melilite leucitites or cecilites, to use an old name of Cordier for them. It falls in the position II.9.2.2, of the quantitative classification, and the name *vesbose* is given to this subrang.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue

PALEONTOLOGY.—*A catalogue of the Mesozoic and Cenozoic plants of North America.* F. H. KNOWLTON. U. S. Geol. Survey Bull. **696**: Pp. 815. 1920.

This volume contains a bibliography of 32 pages, a catalogue of 618 pages, biologic classification of genera, index of genera and families, and floral lists of the North American Mesozoic and Cenozoic plant-bearing formations, covering 118 pages. It is an extension or up-to-date edition of *Bulletin 152* published in 1898. This catalogue should be of inestimable value to paleobotanists. R. W. STONE.

GEOLOGY.—*Conservation through engineering.* FRANKLIN K. LANE. U. S. Geol. Survey Bull. **705**. Pp. 38. 1920.

The annual report of the Secretary of the Interior to the President contained a plea for constructive policies that deserves a hearing also by the engineers and business men who are developing the power resources of the country. The largest conservation for the future can come only through the wisest engineering of the present. The conditions under which the utilization of natural resources is demanded are outlined by Secretary Lane, who recommends a program that calls for the cooperation of engineer and legislator.

The Secretary advocates saving coal by taking more power from each ton, and using each kind of coal for the particular purpose to which it is best adapted. He believes that our water power should be developed and hydro-electric power used instead of coal, and that all power plants serving a common territory should be coordinated. Our petroleum supply is exhaustible and the oil problem should have deliberate attention. A rigid policy of saving oil is urged, and it is argued that we should have a foreign supply of petroleum.

To bring this power inventory to the attention of the men who furnish the country with its coal and oil and electricity, this extract from the Secretary's administrative report is reprinted as a bulletin of the United States Geological Survey.

R. W. STONE.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

BOARD OF MANAGERS

The 234th meeting of the Board was held on November 24, 1919. In accordance with a suggestion transmitted by the Librarian of Congress, a set of the publications of the ACADEMY was sent to the library of the University of Louvain, destroyed by the German army in 1914. At the 235th meeting, on December 22, 1919, a committee consisting of R. L. FARIS, A. KNOPF, S. A. ROHWER, and R. B. SOSMAN was appointed to revise the "free list" of the *Journal*. At the 236th meeting, held on January 26, 1920, the budget for 1920 was adopted, and the following appointments for the year 1920 were announced:

Executive Committee: The *President*, *Treasurer*, and *Corresponding Secretary, ex officio;* WILLIAM R. MAXON and T. WAYLAND VAUGHAN.

Committee on Meetings: H. H. KIMBALL, *Chairman;* W. S. EICHELBERGER, H. L. SHANTZ, J. R. SWANTON, and R. C. TOLMAN.

Committee on Membership: L. A. FISCHER, *Chairman;* W. M. CLARK, S. A. ROHWER, J. N. ROSE, and CARL VOEGTLIN.

Editor of Journal, 1920–1922: ALEXANDER WETMORE.

The Board elected the following *Vice-Presidents* to represent societies which had not presented nominations at the Annual Meeting: *Botanical Society*, LYSTER H. DEWEY; *Institute of Electrical Engineers*, FRANCIS B. SILSBEE; *Columbia Historical Society*, ALLEN C. CLARK; *Medical Society*, FRANCIS R. HAGNER.

At the 237th meeting, held on February 9, 1920, the Board voted funds in payment for the publication of the Preliminary Report of the Federal Government Section of Engineering Council's Committee on Classification and Compensation of Engineers, published by Mr. J. C. HOYT with aid from several of the affiliated societies of the ACADEMY, and distributed to all of their membership. The Standing Rules of the Board were amended to provide for the appointment of the Committee on Meetings in June, instead of in January, as heretofore.

The following persons have become members of the ACADEMY since the last report in the *Journal:*

Mr. SAMUEL TRASK DANA, U. S. Forest Service, Washington, D. C.

Mr. EARL H. FROTHINGHAM, U. S. Forest Service, Washington, D. C.

Dr. FRANCIS R. HAGNER, 900 17th Street, Washington, D. C.

Mr. EDMUND CECIL HARDER, care Republic Mining and Manufacturing Company, 1111 Harrison Building, Philadelphia, Pennsylvania.

Dr. ALEXANDER WETMORE, Bureau of Biological Survey, U. S. Department of Agriculture, Washington, D. C.

ROBERT B. SOSMAN, *Corresponding Secretary.*

PHILOSOPHICAL SOCIETY OF WASHINGTON

824TH MEETING

The 824th meeting was held at the Cosmos Club, November 22, 1919. President HUMPHREYS in the chair; 56 persons present.

Mr. R. C. TOLMAN presented the first paper on *A conception of the business of mathematical physics.*

Like other sciences, Mathematical Physics is in a process of development from a descriptive to a deductive form. As soon as the main body of a science can be handled deductively, it becomes desirable to pick out the most suitable deductive system for this purpose.

In performing this task for Mathematical Physics, use should be made of the methods developed for handling deductive systems, by Pierce, Royce, Mrs. Ladd-Franklin, Russell, Whitehead, and Meinong. The universe of discourse in such systems should be generated from a set of indefinables. These indefinables should be chosen so as to be sufficient for defining all the concepts in the particular branch of inquiry, and, if possible, should be few in number, simple in nature, familiar to previous workers in the field, independent of each other, of course should be applicable, not merely to the generation of the universe of discourse, but also applicable to the particular field of science under discussion.

After the definition of the concepts in the universe of discourse has been completed, a set of postulates should be chosen from which the various theorems of the logical system can be deduced. These postulates should be chosen so as to be sufficient for deducing all the theorems desired, so as to be consistent with one another, if possible, so as to be independent from one another, few in number, simple in nature, self-evident if possible, familiar, and of course must be true, *i. e.*, applicable to the particular field under investigation.

For defining the subject matter of Mathematical Physics, the fundamental relation "is greater than," five fundamental kinds of magnitude—mass, length, time, charge, entropy—and five fundamental

operations—addition, multiplication, inner multiplication, outer multiplication, and differentiation—may be chosen as indefinables.

As postulates for Mathematical Physics, we may choose:

1. The principle of dimensional homogeneity.
2. The principle of the relativity of size. (Similitude.)
3. The principle of the relativity of motion.
4. Hamilton's principle. (Corollary Conservation of Energy.)
5. The principle of the constant velocity of light.
6. The principle of the indivisibility of the electron.
7. The principle of entropy increase.
8. The principle that crystals have zero entropy at the absolute zero.
9. Some principle for quantum action which is not yet known.

These postulates furnish the methods of operation for handling the greater bulk of the material treated in Mathematical Physics.

Discussion: The paper was discussed by Messrs. HUMPHREYS, HAWKESWORTH, LLOYD, HULL, FOOTE, BAUER, WHITE, AGNEW, and TUCKERMAN.

Mr. E. F. MUELLER next presented a paper on *The standard scale of temperature* by C. W. WAIDNER, E. F. MUELLER, and P. D. FOOTE.

The standard scale of temperature which it is attempted to realize in practice is the centigrade thermodynamic scale. Owing to the experimental difficulties involved in the use of the gas thermometer, it is necessary to establish a working scale, which should represent the thermodynamic scale as closely as is possible in the light of existing knowledge. It is equally important, however, that the working scale be characterized by a high degree of definiteness and reproducibility. The working scale is defined by means of certain fixed points, such as freezing or boiling points, and by specifying the method of interpolation between the fixed points. In 1914, the three leading national laboratories, the Physikalish-Technische Reichsanstalt, the National Physical Laboratory and the Bureau of Standards had practically agreed on the details of a working scale. While the scale was not formally adopted, each laboratory has adopted it independently, there being only minor differences between the three. In the interval —190 degrees to +450 degrees, the fixed points are those defined by the boiling point of oxygen, sublimation point of CO_2, freezing and boiling points of water, and the boiling point of sulphur, and the platinum resistance thermometer is used as the interpolation instrument. In the interval 450 degrees to 1100 degrees the platinum—90 per cent platinum, 10 per cent rhodium thermocouple is used as interpolation instrument, being calibrated at the freezing points of zinc, antimony and copper. A number of fixed points in addition to those given were also agreed upon.

In the negotiations between the laboratories, no attempt was made to define a scale above 1100 degrees. Present practice, however, tends toward using the disappearing filament type of optical pyrometer as an

interpolation instrument, using one or more metal freezing points for calibration. An outstanding discrepancy of 7 degrees in the values obtained by different methods for the melting point of palladium makes the adoption of uniform scale for temperatures above 1200 degrees a difficult matter at present.

Discussion: The paper was discussed by Messrs. WHITE, ADAMS, TOLMAN, and TUCKERMAN.

The Society adjourned at 10.06.

S. J. MAUCHLY, *Recording Secretary.*

ENTOMOLOGICAL SOCIETY OF WASHINGTON

322ND MEETING

The 322nd regular meeting of the Society was held in the auditorium of the Cosmos Club on May 1, 1919. Vice-President WALTON was in the chair and there were present sixteen members and one visitor.

The regular program was as follows:

A. B. GAHAN: *The black grain-stem sawfly of Europe in the United States.* This paper dealt with *Trachelus tabidus* (Fab.), the establishment of which in the United States has been recently discovered. This insect may become a serious pest of small grains, especially wheat. Some of the points discussed were distribution both in the United States and in the Old World, character of injury, description of adult and larva, and a comparison with related species, suggestions for control, and bibliography. The illustrations consisted of drawings of the adult, the larvae of this and two allied species of similar habit, and a map of the distribution in the United States.

In the discussion Mr. WALTON stated that Mr. MCCONNELL of the Bureau of Entomology had discovered a parasite that killed as high as 30 per cent of the sawfly larvae. Dr. QUAINTANCE remarked that this appears to be one of the few cases in which the necessary means for insect control conflict with good agricultural practice, the rotation of clover and wheat being undoubtedly good agricultural practice and also favoring reproduction of the insect. Mr. WALTON took exception to this, stating that forage experts claim that better clover can be grown on plowed land; but planting on stubble is easier and cheaper. Mr. ROHWER stated that sawflies are sluggish fliers and was of the opinion that if in the rotation, fields to be planted to grain were far apart, the infestation would be considerably reduced. Mr. GAHAN thought that the fact that the species is already widely distributed in both mountain and plains regions indicates considerable ability to spread. Winds as a means of spread being suggested, Mr. ROHWER stated it as his experience that sawflies seek shelter in high winds. He also stated that the species is possibly more widely distributed than outlined by Mr. GAHAN, inasmuch as he has a larva from near Parkersburg, West Virginia, that is probably this species.

Notes and Exhibition of Specimens

Mr. SCHWARZ gave an account of a recent visit which he and several other entomologists had made to the Florida everglades and keys. He described the topography and flora of the region, especially contrasting the character of the everglade keys with the Florida Keys. He spoke of the occurrence in semitropical Florida of the coleopterous genus *Dendrocinus* (family Scolytidae). The type of this genus, *D. globosus* Eichoff, was described in 1868 from two specimens said to have come from "North America," but the correctness of this locality has always been doubted. However, during this visit to Florida Mr. H. S. Barber found an undescribed species of the genus at Marathon (Key Vacas) boring in the solid wood of *Bourreria havaniensis*. This species differs greatly from *D. globosus* and the other species of the genus, and Mr. Schwarz presented a description of it for publication in the proceedings.

Mr. CUSHMAN discussed the larva of the spider parasite, *Polysphineta texana* Cresson, describing its method of maintaining its hold on its host.

Dr. BAKER discussed the probable synonymy of *Neotoxoptera violae* Theob. of Egypt with *Rhopalosiphum violae* Pergande of America on the ground that forms similar to the former can be produced in greenhouses in this country. Mr. ROHWER thought that the fact that a form of the American species resembling the African form can be produced in greenhouses was no proof that the American and African forms are the same species. He objected to the synonymizing of the two until further proof of their identity is obtained. In support of his contention he cited the case of the so-called *Cladius pectinicornis*, one of the rose-slugs, stating that the American form, which has heretofore been considered as the same as the European species, is specifically distinct. Mr. HEINRICH agreed with Mr. ROHWER, stating that in the Microlepidoptera American species are being rapidly found distinct, so that the European names are taken out of American literature.

323D MEETING

The 323d regular meeting was held at the Cosmos Club on June 5, 1919. President SASSCER presided and there were present twenty-four members and six visitors.

The program offered was as follows:

R. H. HUTCHINSON: *Experiments with steam disinfection in destroying lice in clothing.* Mr. Hutchinson prefaced his paper with some remarks about the louse, showing lantern slides illustrating sexual characters, eggs, hatching, and the effect of steam on eggs. Further slides were then thrown on the screen showing field laundry units and a large delousing station used at debarkation camps, the speaker explaining in detail all the different processes and apparatus.

Major HARRY PLOTZ, U. S. Army, told of some of his experiences in connection with this work in Bulgaria in the early part of the war. Dr. BAKER was interested in the presence, mentioned by Mr. Hutchinson, of the peculiar yellow body in the nymphs of the louse and the fact that

it has not been recorded in the literature of the louse. A similar body, he said, always occurs in several groups of Homoptera that he had studied. Its forerunner is present in the egg and is carried to the interior at the time of invagination. In parthenogenetic forms its history is associated with the development of the ovaries. Buckner considered it a commensalistic organ, but this view is not held by all embryologists.

A. N. CAUDELL: *Notes on Zoraptera.* A discussion of the biology and systematics of this peculiar group of insects. Points of particular interest were the finding of winged forms by Mr. H. S. Barber and the fact that the insects have the habit of dealation.

G. C. CRAMPTON: *Phylogeny of Zoraptera.* Presented by title.

324TH MEETING

The 324th regular meeting of the Society was held October 2, 1919, in the auditorium of the Cosmos Club. Vice-President GAHAN presided and there were present twenty-three members and six visitors.

The following program was given:

HARRY F. DIETZ: *Notes on the insect fauna of Panama.*

This was an account of Mr. DIETZ's observations in the canal zone, especially on the scale-insects *Aleurocanthus woglumi* and *Coccus viridis*, and on termites of various species. The talk was copiously illustrated by lantern slides.

In the discussion of this paper Mr. SCHWARZ spoke of the entomological exploration of the Canal Zone, especially of that by Motschulsky and Leconte and the collaborators of the Biologia Centrali-Americana, as well as the more recent Smithsonian Expedition including Messrs. Schwarz and Busck.

H. F. WICKHAM: *Two new Carabidae from Alaska.*

In presenting this paper Mr. SCHWARZ spoke of the knowledge of the Coleoptera of Alaska, dwelling more especially on the collections made by Dr. Eschscholtz and those made under the guidance of Count von Mannerheim. He pointed out that all the early explorations were on the southern coast of Alaska including the islands of the Bering Sea. The two species of *Tachypus* described in Prof. Wickham's papers were collected in the interior, where the fauna is radically different from that of the coast region. Mr. SCHWARZ also gave a short account of Motschulsky's trip to North America as published by that author in his letters to Ménétriéz.

Dr. HOWARD introduced Dr. S. I. KUWANA, the famous Japanese entomologist, who addressed the Society briefly in Japanese and in English in appreciation of his trip about the United States in search of entomological methods and ideas.

Notes and Exhibition of Specimens

Dr. ALDRICH spoke of the problem in distribution offered by the Ephydrid fly, *Lipochaeta slossonae* Coq. This fly lives along the margin of the Atlantic Ocean from New Jersey southward and along the Gulf coast, reappearing at Long Beach in Southern California. He did not know whether it occurs around the coast of South America or if its distribution is discontinuous.

Dr. HOWARD reported that Mr. Austin H. Clark had taken a specimen of the West Indian moth, *Thysania zenobia*, in Washington on September 29, and that another specimen had been reported on September 22.

325TH MEETING

The 325th meeting of the Society was held in the Lecture Hall of the Cosmos Club on November 6, 1919. President SASSCER presided and there were present thirty-three members and four visitors. New members elected: LESTER L. SPESSARD and HENRY Y. GOULDMAN of the Federal Horticultural Board; CHARLES H. RICHARDSON and ERNEST L. CHAMBERS of the Bureau of Entomology; and RYOICHI TAKAHASHI of the Forest Experiment Station, Meguro, Tokio, Japan.

The regular program was as follows:

L. O. HOWARD: *On entomologists*. This paper was an historical review of the development of entomology from the purely systematic museum work to the intensely scientific biological and economic phases of the science of the present day. Taking as a text "The systematic entomologist must be an all-round entomologist; the economic entomologist must be an all-round entomologist; and both systematic and economic entomologists must be all-round men," Dr. Howard showed the interdependence of all phases of the science, and the fact that the economic entomologists are coming more and more to realize their dependence upon the systematists. The change in the attitude of other branches of science and of the layman toward the entomologist and the factors that have caused the change were also brought out.

Many of the members of the Society expressed their appreciation of Dr. Howard's paper. Dr. QUAINTANCE thought that economic entomology has kept pace with other branches of science. When the experiment stations were established there were no trained entomologists and it was necessary to call on men in other professions who had a general knowledge of biology. In course of time textbooks were published, courses were established in colleges, and entomological papers improved. In more recent years entomologists have contributed some of the best biological papers in any line. As for personal characteristics he thought there was no more wholesome and sociable group of men. Mr. SCHWARZ stated that some of the earliest American entomological publications, even catalogues, contained items on the economic phase of the science.

Dr. HOPKINS commented on the contributions of entomologists to biology and paid a personal tribute to Dr. Howard in the following words: "Dr. Howard has not referred to the entomologist who has done more to command the recognition of the broad aspects of entomological research as related to other sciences and to practice in agriculture and medicine, and who has also done more to command respect for entomology and entomologists by scientists and the public in general than any other. Dr. Howard, through his liberal policy as Chief of the Bureau of Entomology, and his helpful personal interest and counsel, deserves far more credit for the achievements of other entomologists in and out of the Bureau than has been recognized or perhaps ever will be.

He has not only offered unlimited opportunities for the exercise of initiative and the pursuing of original lines of research leading in all directions, and sometimes penetrating deeply into his own fields of investigation, but has given personal advice and made suggestions that have pointed the way to rapid progress in the achievement of results. We are all (especially the older members of the Society) familiar with the very large number of contributions in *Insect Life*, bulletins of the Division and Bureau of Entomology, and his monumental work, systematic and economic, on parasitic Hymenoptera and mosquitoes, and on other insects in their relation to the health of man, which stand as striking examples of the service entomology has rendered to humanity and to the general advancement of biological knowledge. I want to take this opportunity to acknowledge and express my gratitude and appreciation of the opportunities and facilities that have been offered to take up and pursue the lines of work that have been of greatest interest and pleasure to me."

Dr. BAKER called attention to the change in the attitude of medical men brought about by the war and to the function of entomologists in the war in connection with camp sanitation. Mr. ROHWER told of an entomologist of the old school who complained that taxonomy is not what it formerly was. Mr. Rohwer agreed but stated that the taxonomist has progressed and broadened. Mr. HEINRICH feared that the greater recognition of economic entomology would prove disadvantageous to taxonomy and that the taxonomist of the future will have to be very self-sacrificing from a financial standpoint. Dr. HOWARD took exception to this, stating that the economic men appreciate the need of accurate taxonomic work.

The second paper on the program was as follows:

CARL HEINRICH: *A new genus of Oecophorid moths from Japan.*

Notes and Exhibition of Specimens

Mr. HYSLOP called attention to the recent death of Mrs. C. H. Fernald, author of the "Catalogue of the Coccidae of the World."

Mr. HEINRICH exhibited photographs of the camp where Emerson L. Diven, who had been engaged in aeroplane scouting in connection with the work on the pink boll-worm of cotton, and his pilot were killed in an aeroplane accident.

Mr. CAUDELL told of stridulation by the severed legs of the common house centipede and also of the stridulation of a cockroach. The legs of the centipede move very rapidly for a time after being removed from the body, the sound being caused by the rubbing of a spine on the basal joint against the next joint. Dr. HOPKINS and Mr. SCHWARZ spoke of the stridulating organs of the scolytid beetles, some of which have these organs on the sides of the body while others have them on the head. In some species the males have these organs on the head and the females have them at the anal end.

Mr. SCHWARZ told of a monument erected to the boll weevil in Alabama.

Dr. BAKER spoke of finding an aphid on chestnut at Falls Church, Virginia, which was otherwise known to him only from one slide of specimens taken on guava, and that it had since disappeared from chestnut. This reminded Dr. HOPKINS of a gnat that was discovered associated with potato-scab that had never been rediscovered.

Dr. QUAINTANCE called attention to the change of habit of the codling moth in attacking walnuts in California. It has become a serious problem and is revolutionizing the industry.

Dr. HOPKINS stated that if an insect common to several hosts breeds for a number of generations on one host it will not go to another. This fact is taken advantage of in forest practice against certain scolytids.

Dr. CRAIGHEAD told of his experiments in transferring cerambycids from one host to another and of the difficulty in inducing them to go back to their normal hosts.

Mr. HEINRICH stated that the codling moth belongs to the most plastic group in the microlepidoptera, and cited as an example the eastern *Evetria frustrana*, which if transferred to the western Jack pine develops into *Evetria bushnelli*.

Dr. G. P. ENGELHART of the Brooklyn Museum was introduced by the president and addressed the Society briefly concerning his work at that institution.

Mr. ROHWER criticised the lack of short notes by the younger members of the Society. These men, he thought, being largely engaged in field work, should have opportunity to make many observations of interest and should present them at the meetings.

R. A. CUSHMAN, *Recording Secretary.*

Ground was broken on April 5 for the new building of the Medical Society of the District of Columbia, to be erected on M Street between Seventeenth Street and Connecticut Avenue.

The Weather Bureau's earthquake summary shows that 87 earthquakes of appreciable intensity occurred in the United States in 1919, as compared with 127 in 1918. As usual, a considerable number of quakes (10) during this year occurred in the Mississippi Valley region. One earthquake occurred near Front Royal, Virginia, but was less intense than the one of 1918 which was central in the same general region and which was felt in the District of Columbia.

During the development of an optical method for studying recording instruments, it has been found at the Bureau of Standards that the photographic records obtained furnished incidentally an excellent means of determining the uniformity of motion of the clockwork used to drive the recording mechanism. A study of this feature has been undertaken using clockwork of foreign and domestic manufacture, and it is believed that the method will prove to be directly applicable to chronographs.

The Bureau of Standards has completed arrangements to test the comparative durability of upper leather made from shark and porpoise skins as compared with that from calfskin and cowhide. The cooperation of the National Boot and Shoe Manufacturers' Association has been secured in the making of the necessary shoes for the tests.

Dr. LYMAN J. BRIGGS, formerly physicist in the Bureau of Plant Industry, U. S. Department of Agriculture, who has been on temporary assignment to the Bureau of Standards for research on aeroplane problems during the war, was transferred permanently to the staff of the Bureau of Standards in January.

Mr. JOHN B. FERGUSON, formerly of the Geophysical Laboratory, Carnegie Institution of Washington, and now a member of the research department of the Western Electric Company of New York City, has accepted a position as Associate Professor of Chemical Research at the University of Toronto, Toronto, Canada. He will assume the new position in July.

Mr. L. H. GREATHOUSE, of the U. S. Fixed Nitrogen Research Laboratory, resigned on March 31 to accept a position with the Atmospheric Nitrogen Corporation in New York City. This corporation has been organized by the General Chemical Company and the Semet-Solvay Company.

Dr. P. J. S. CRAMER, of Java, known for his studies on the culture of rubber, visited Washington in March.

Mr. H. D. McCaskey resigned from the U. S. Geological Survey in March to assume charge of the Bora Da Orchards at Central Point, Oregon.

Prof. E. B. Matthews, of the National Research Council, and Mr. M. O. Leighton, National Service Representative of Engineering Council, have been authorized by the recently created Board of Surveys and Maps to organize an advisory council to the Board, consisting of representatives of engineering, geographic and other organizations, which shall represent the public and the professions in the presentation and discussion of unofficial demands and needs in connection with the mapping work of the United States.

Dr. M. E. Pennington, formerly chief of the food research laboratory of the Bureau of Chemistry, U. S. Department of Agriculture, has become manager of the research and development division of the American Balsa Company, Inc., at 50 E. 42d Street, New York City.

Dr. H. C. Puckett, of Seattle, Washington, visited the laboratory of the Division of Physical Anthropology, Smithsonian Institution, in March, for the purpose of examining the teeth in skulls of various primitive peoples, and gathering information which will aid in determining the cause of early decay in human teeth. He finds but little indication of decay in the teeth of aborigines, a fact accounted for, he believes, by the coarseness of the food they consumed. White flour, soft foods and insufficient mastication are considered by him to be responsible for the relatively large proportion of defective teeth among highly civilized peoples.

Vocal Range